

THE PARAMPHISTOMES (TREMATODA) OF AUSTRALIAN RUMINANTS.

PART I. SYSTEMATICS.

By P. H. DURIE, B.Sc.,

Division of Animal Health and Production, C.S.I.R.O., Veterinary Parasitology
Laboratory, Yeerongpilly.

(Plates iv-v.)

[Read 26th April, 1951.]

Synopsis.

A study has been made of the species of Paramphistomidae occurring in the rumen and reticulum of Australian cattle.

Identifications were based on the system devised by Näsmark 1937, involving an examination of the acetabulum, genital atrium and pharynx, as seen in median sagittal sections.

The species previously known as *Paramphistomum cervi*, was found to consist of *Ceylonocotyle streptocoelium* (Fischoeder, 1901) Näsmark, 1937, and *Calicophoron calicophorum* (Fischoeder, 1901) Näsmark, 1937, whilst the species previously known as *P. cotylophorum* was determined as *P. ichikawai* Fukui, 1922. A fourth species was present among the material examined but as yet remains undetermined.

In view of the importance given by Edgar (1938), Roberts (1934), Ross and Gordon (1936) to Paramphistomes as causal agents of parasitic gastro-enteritis in sheep and cattle in Australia, investigations were commenced into their bionomics, pathogenicity, and control. Three species of Amphistome flukes have been recorded from Australian cattle (Seddon, 1947), namely, *Paramphistomum cervi* (Zeder, 1790), *P. explanatum* (Creplin, 1847), and *P. cotylophorum* (Fischoeder, 1901). *P. cervi* is recorded from Queensland, New South Wales, Victoria, Western Australia and Tasmania; *P. explanatum* from Queensland; and *P. cotylophorum* from Queensland and New South Wales. *P. cervi* and *P. cotylophorum* are noted as occurring also in sheep.

The author (Durie, 1949) published a preliminary note implicating the Planorbid snails, *Glyptanissus gilberti* and *Segnitilia alphaena* as the intermediate hosts of *P. cervi* and *P. cotylophorum* respectively. These observations were based on the recovery of flukes, identified as those two species, from lambs fed cysts obtained from naturally infested snails. Subsequent attempts to infest snails experimentally with miracidia, considered to be those of *P. cervi*, were unsuccessful, and it seemed evident that the flukes that had been identified as *P. cervi* probably consisted of more than one species. A careful, taxonomic study of the Australian species was therefore considered essential before further work on the bionomics of these parasites could be attempted.

MATERIALS AND METHODS.

The bulk of the material examined has been collected from the rumen and reticulum of cattle slaughtered at abattoirs near Brisbane, Queensland, and drawn from the coastal and sub-coastal areas of the State. Additional material has been obtained from other States through the courtesy of slaughtering inspectors and veterinary research laboratories.

It is evident from the literature, Fischoeder (1901), Stiles and Goldberger (1910), Maplestone (1923), Travassos (1934), Dawes (1936, 1946) and Näsmark (1937), that the family Paramphistomidae is a very difficult one from the systematic point of view. This has been discussed fully by Näsmark (1937), who attempted to obtain a clearer conception of the family's classification by careful studies on serial sections, particularly median sagittal sections, in which attention was largely directed to the muscle structures of the acetabulum and pharynx.

Näsmark's system has been used by the author in the studies reported here and is considered a satisfactory one, at least, in so far as the Australian species are concerned.

The measurements of body length and breadth were made on entire specimens fixed in Carnoy's fluid, whereas all other measurements were made on median sagittal sections. Ova dimensions were obtained from eggs deposited in physiological saline.

It was noted very early in these studies that *Gigantocotyle* (*Paramphistomum*) *explanatum* (Creplin, 1847) Näsmark, 1937, was not represented in the Australian material under examination. This species has a readily recognized and distinct musculature of the acetabulum and pharynx (Näsmark, 1937), and specimens received from Ceylon were easily identified on this character. *G. explanatum* occurs in the gall bladder and bile ducts of bovines (Dawes, 1946; Näsmark, 1937). In view, therefore, of the absence of reports from Australia of amphistomes occurring in these parts of the body, together with the fact that the species was not represented among the hundreds of amphistomes obtained for examination from various parts of Australia, it is highly probable that *G. explanatum* is not present in this country and that records of its occurrence by Roberts (1934) and Ross and Gordon (1936) are erroneous.

Two and possibly three species have been recognized among the flukes previously identified as *P. cervi*. *Calicophoron calicophorum* (Fischoeder, 1901) Näsmark, 1937, is very common and widespread and is probably the most prevalent amphistome in Australian cattle. *Ceylonocotyle streptocoelium* (Fischoeder, 1901) Näsmark, 1937, is the second species, whereas the third species as yet remains undetermined, but appears to be closely related to *C. calicophorum*.

A re-examination of the species previously recorded in Queensland and New South Wales as *Paramphistomum cotylophorum* has shown it to be *Paramphistomum ichikawai* Fukui, 1922. A detailed description of each of these species is given below.

CEYLONOCOTYLE STREPTOCOELIUM (Fischoeder, 1901) Näsmark, 1937.

Host: *Bos taurus*—rumen and reticulum.

Distribution: Beaudesert, Queensland; Gympie, Queensland.

Length 4.5 mm. (3.0–5.0 mm.), breadth 2.4 mm. (2–3 mm.); D.V. measurement 1.4 mm. (1.1–1.8 mm.); dorsal line curved, curvature greater in the posterior third of the body; ventral line plain to slightly concave. Acetabulum conforms to Näsmark's *Streptocoelium* type opening postero-ventrally, its maximum diameter 1.0 mm. (0.7–1.2 mm.), the ratio of its diameter to body length being 1:4.5 (1:3.5–1:5.0). Pharynx conforms to Näsmark's *Paramphistomum* type, 0.40 mm. (0.30–0.46 mm.) in length; ratio of pharynx length to body length 1:10.0 (1:9–1:12). Oesophagus 0.22 mm. (0.17–0.25 mm.) in length; oesophageal sphincter present. Genital atrium with genital sphincter, conforms to Näsmark's *Streptocoelium* type; ratio of genital atrium to acetabulum diameter 1:3.9 (1:3.5–1:4.5). Testes moderately lobed, oval to rectangular in shape, situated tandem and measuring 0.5 mm. in length and 1.0 mm. in D.V. direction. Egg 0.148 × 0.074 mm. (0.154 × 0.070 – 0.145 × 0.078 mm.).

Acetabulum (Pl. iv, fig. 1).—The acetabulum conforms to Näsmark's *Streptocoelium* type. The circular muscle series are characterized by their relatively few muscle units, with the interior series presenting a greater number than the exterior series. There is no division into de_1 and de_2 circular. de and di circular correspond closely in structure and in the number of units to ve and vi circular. The de series shows a slight variation in the size of the units, these being smaller externally and increasing in size internally. The number of units present in 10 specimens is shown in Table 1.

Pharynx.—The pharynx conforms to Näsmark's *Paramphistomum* type. The internal circular muscle layer consists of small closely packed units. The internal surface of the pharynx is smooth or with very small papillae. The interior longitudinal layer appears as a clearly developed band and extends inwards for about one-quarter the width of the pharynx. The middle circular layer is absent. The radial muscles are not strongly developed but are clearly visible. The exterior circular layer is rather indistinct with small units. The exterior longitudinal layer is indistinct and narrow. The basally circular layer is strongly developed and the series appear to be arranged in two rows. A slight trace of the anterior sphincter is present, but both the lip sphincter and posterior sphincter are absent.

Genital Atrium (Pl. iv, fig. 2).—The genital atrium of this species is much smaller than that of *P. ichikawai*, and possesses both a genital sphincter and sphincter papillae.

The genital papilla is rather thick and variable in shape. Sphincter papillae, although present, are not as strongly developed as described by Näsmark (1937). The genital sphincter consists of several bundles of closely packed fibres. It is quite conspicuous, but again not as strongly developed as described by Näsmark (1937). The ventral atrium is only slightly developed.

TABLE I.
C. streptocoelium: Unit Series of Circular Musculature of the Acetabulum from a Median Sagittal Section.

de.	di	vi	ve
12	32	37	15
14	30	25	15
17	32	29	15
15	30	27	13
15	30	30	14
14	31	22	12
12	28	25	13
14	29	26	14
13	31	28	14
17	32	26	13

Discussion.

The specimens differ from Näsmark's description mainly in body length (7.6 mm.), but the measurements of the pharynx and other structures, except the oesophagus, agree closely with his description. Consequently any ratios given by Näsmark involving body length are greater than those given by the author.

Body length is regarded as a useful character to define the approximate size of a species, and to differentiate species which vary greatly in size. However, the length of the body in living specimens is an extremely variable one, as flukes actively elongate and contract continually. In fixed specimens the body length may vary according to the type of fixative and method of fixing employed and is therefore considered unsuitable for determining critical ratios.

In specimens belonging to the genus *Ceylonocotyle* Laurer's canal and the excretory canal (Pl. iv, fig. 3) do not cross one another, a character shared also by the genera *Nilocotyle* (Näsmark, 1937) and *Buxifrons* (Näsmark, 1937). *Ceylonocotyle* may be separated from these, however, by certain features of the acetabulum, and particularly by the absence of strongly developed radial muscles.

C. streptocoelium may be distinguished from other members of the genus by the absence of a strongly developed oesophageal bulb and lip sphincter, and from the closely allied *C. orthocoelium* by the presence of a genital sphincter and an oesophageal sphincter (Pl. iv, fig. 4). In the living state it may be separated from *P. ichikawai*, which it resembles closely in size, colour and shape, by the absence of any noticeable thickening around the genital pore. Both species are found in the rumen, with *C. streptocoelium* in the reticulum as well.

The genital atrium in the specimens examined differed slightly from the description of the *Streptocoelium* type given by Näsmark (1937), but this is probably due to the fact that Näsmark's material was poorly preserved.

The relationship between dimensions of the pharynx, genital atrium and acetabulum is shown in Plate v, figure 5.

PARAMPHISTOMUM ICHIKAWAI Fukui, 1922.

Host: *Bos taurus*—rumen only.

Distribution: Coastal districts, Queensland.

Length 5.7 mm. (3.12–7.0 mm.), breadth 2.7 mm. (2–3 mm.); D.V. measurement 1.80 mm. (1.40–2.17 mm.); dorsal line slightly curved, but more strongly so in posterior two-thirds; ventral line plain to slightly concave (Pl. v, fig. 6). Acetabulum conforms to Näsmark's *Paramphistomum* type, opening postero-ventrally, its maximum diameter 1.3 mm. (1.12–1.50 mm.), and the ratio to body length is 1:4.3 (1:3.8–1:4.7). Pharynx conforms to Näsmark's *Paramphistomum* type, 0.60 mm. (0.52–0.80 mm.) in length; ratio of pharynx length to body length 1:9.5 (1:8.2–1:13.2), oesophagus 0.28 mm. (0.17–0.50 mm.) in length. Genital atrium conforms to Näsmark's *ichikawai* type, measures 0.53 mm. (0.45–0.62 mm.) in external diameter; ratio of genital atrium diameter to acetabulum diameter 1:2.5 (1:2–1:2.9). Testes 0.75 mm. long by 1.0 mm. in D.V. direction, lobed, oval, somewhat "shamrock" shaped, and are situated tandem to each other. Egg 0.143 × 0.064 mm. (0.129 × 0.067–0.148 × 0.059).

Acetabulum (Pl. v, fig. 7): The acetabulum conforms to Näsmark's *Paramphistomum* type. The dorsal, exterior, circular series is divided into de_1 and de_2 circular. The ventral exterior circular series corresponds to de_1 circular and shows no division into two groups. The de_1 circular series is well developed and is strongest outwards. The division between de_1 and de_2 circular is fairly clearly marked. The de_2 circular series is weakly developed in comparison to de_1 circular with the units spaced at irregular intervals. The di series is well developed, with units attaining their maximum size in the centre. vi circular corresponds closely in structure and number to di circular, and ve circular corresponds similarly to de_1 circular. The number of units in each series was found to be variable, especially in regard to de_2 circular, and, in some cases, considerable difficulty was experienced in obtaining an accurate count. The acetabulum, however, conformed to Näsmark's *Paramphistomum* type plan in all specimens examined, and the musculature was more strongly developed than in *C. streptocoelium*. The number of unit series in each group taken from 10 specimens is shown in Table 2.

TABLE 2.

P. ichikawai: Unit Series of Circular Musculature of the Acetabulum from a Median Sagittal Section.

de_1 .	de_2 .	di	vi .	ve .
23	6	40	48	17
19	9	43	42	14
19	8	46	48	15
20	8	43	43	16
20	8	39	43	17
20	5	36	37	17
23	12	43	44	18
19	9	40	46	15
19	10	31	38	20
20	3	37	46	16

Pharynx: The pharynx conforms to Näsmark's *Paramphistomum* type. The internal circular muscle layer consists of small units increasing slightly in size towards the anterior end. The internal surface of the pharynx is papillated slightly in the anterior portion. The interior, longitudinal layer extends inwards to about one-third the width of the pharynx; the interior margin is clearly defined. The middle circular layer is absent. The radial musculature is clearly visible but not strongly developed. The exterior circular layer is somewhat indistinct anteriorly but clearer towards the posterior end. The exterior longitudinal layer is narrow but clearly visible. The basally circular layer contains small units which lie in two rows towards the interior edge. The anterior sphincter, lip sphincter and posterior sphincter are absent.

Genital Atrium (Pl. v, fig. 8): The genital atrium belongs to Näsmark's Group II B1, which embraces forms with no genital sphincter, but with sphincter papillae. The genital papillae are thick and clumsy. The genital atrium conforms to Näsmark's

ichikawai type. The tissue of the walls of the genital atrium is thick and muscular, with well-developed radial musculature, and could quite easily be mistaken for a sucker. This is particularly the case in living specimens, where the structure shows a typical "sucker-like" appearance. However, sections show that, although the atrium tissue is clearly divided from the rest of the body tissue, a true delimiting membrane, characteristic of the genus *Cotylophoron*, is lacking.

Specimens of this species in the living state are pink to white in colour and appear to be confined to the rumen, as they have never been observed attached to the reticulum, even when heavy infestations are present. They closely resemble *C. streptocoelium* in size and colour, but may be distinguished from that species by the "sucker-like" genital atrium.

Discussion.

The above description agrees closely with that of Näsmark for *P. ichikawai* but differs slightly in body length dimensions. Measurements of other structures are in close agreement. The remarks made in regard to body length in the description of *C. streptocoelium* apply equally to this species. *P. ichikawai* exhibits a remarkably constant ratio between the genital atrium diameter and acetabulum diameter, and differs markedly from *C. streptocoelium* in this respect.

CALICOPHORON CALICOPHORUM (Fischoeder, 1901) Näsmark, 1937.

Host: *Bos taurus*—rumen and reticulum.

Distribution: Coastal and sub-coastal regions of Queensland, New South Wales, Victoria, Western Australia, South Australia and Tasmania.

Length 11.1 mm. (10–12 mm.), breadth 6.6 mm. (5.8–7.5 mm.); D.V. measurement 2.9 mm. (2.1–3.9 mm.); dorsal line evenly curved, truly conical in shape, with maximum breadth at the posterior end; ventral surface slightly concave. Acetabulum conforms to Näsmark's *Calicophoron* type, 2.4 mm. (1.60–3.2 mm.) in diameter; ratio of acetabulum diameter to body length 1:4. Pharynx conforms to Näsmark's *Calicophoron* type, 1.4 mm. (0.93–1.5 mm.) in length; ratio of pharynx length to body length 1:8. Oesophagus 0.9 mm. (approx.). Testes placed diagonally side by side, deeply lobed. Genital atrium conforms to Näsmark's *Calicophoron* type. Egg 0.133 × 0.080 mm. (0.126 × 0.072–0.147 × 0.090 mm.).

Acetabulum: The acetabulum conforms to Näsmark's *Calicophoron* type. The circular musculature is well developed and the dorsal, exterior, circular layer is not divided into de_1 and de_2 circular. In this species the circular musculature of the dorsal half of the acetabulum corresponds almost exactly to the musculature of the ventral portion. The de circular layer is well developed and consists of large well-formed units, largest in the centre and decreasing in size interiorly and exteriorly. The units of the di circular layer reach their maximum size close to the exterior edge and gradually decrease interiorly. ve and vi circular correspond to de and di series. The number of units in the circular musculature is shown in Table 3.

Another series of units (Pl. v, fig. 9) is present in this type of acetabulum, which has not been described in any of the other types of Näsmark (1937). This series consists of small units, about 15 in number and about one-tenth the size of the largest units of the other circular musculature. It connects the exterior ends of de and di circular in the dorsal half with a corresponding series connecting ve and vi circular in the ventral portion. As this series has not been previously described, the term lateral, circular layer is proposed.

Pharynx: The ventral, circular, muscle layer consists of very small, closely packed units, increasing slightly in size towards the posterior end. The interior, longitudinal layer is narrow and rather indistinct in comparison with that in the *Paramphistomum* type, and the interior border is not clearly marked. The middle, circular layer is absent. The radial muscles are single fibres showing little ramification. The exterior, circular layer is indistinct, with the units somewhat diffuse and not clearly visible. The exterior, longitudinal layer is narrow but distinct. The basally circular layer is

weakly developed and is confined to a single row of units. A trace of the anterior sphincter is present, but the posterior sphincter and the lip sphincter are absent.

Genital Atrium (Pl. v, fig. 10): The genital atrium conforms to Näsmark's *Calicophoron* type and is highly characteristic of the species (Näsmark, 1937), forming a useful diagnostic character in living flukes. It is eversible and may either be found protruding from the genital region of the body, surmounted on a genital pillar, or retracted well within the body, as illustrated in Plate v, figure 10. Surrounding the genital pore or pillar, depending on the degree of contraction of the atrium, is a flattened circular area, bounded by a small circular ridge and, in living specimens,

TABLE 3.
C. calicophorum: Unit Series of Circular Musculature of the Acetabulum from a Median Sagittal Section.

de.	di.	vi.	ve.
13	40	44	18
12	41	45	16
18	40	41	16
13	36	39	13
20	45	48	25
23	44	48	27
21	46	50	23

swift circular waves of contraction are visible passing around the area. The genital sphincter is well marked and consists of closely packed units, the radial musculature being strongly developed. The sphincter papilla is also well developed and appears as a large closely packed area at the base of the genital papilla. Both the genital sphincter and sphincter papillae are more strongly developed than in either *C. streptocoelium* or *P. ichikawai*.

Discussion.

Näsmark (1937) described two species in the genus *Calicophoron*, namely, *C. calicophorum* and *C. ijimai*, which differ only in regard to the pharynx. Apart from purely anatomical differences, he gives a range of pharynx length measurements for both species which, in his opinion, are distinct enough to differentiate between them. His measurements are 1.50–2.0 mm. for *C. calicophorum* and 0.95 mm. (average of six specimens) for *C. ijimai*. Measurements of pharynx length made by the author on Australian specimens identified as belonging to the genus *Calicophoron* gave a range of 0.73 mm. to 1.50 mm. with lengths occurring throughout the range. This suggests that the pharynx is of the type belonging to *C. ijimai*.

According to Näsmark (1937), the pharynx of both species varies anatomically in several respects, particularly with regard to the interior, circular, muscle layer and to the presence of a well-marked posterior sphincter. Specimens of *C. ijimai* have both these characters strongly developed, while in *C. calicophorum* these structures are poorly developed or absent. In the series examined by the author the pharynx of some specimens varied in the size of the interior circular layer, but in no instance was a well-developed posterior sphincter seen.

In view of this lack of agreement with Näsmark's description of *C. ijimai*, and also because the type material of *C. calicophorum* was obtained from Queensland by Fiscoeder, it has been tentatively decided to consider the species as *C. calicophorum* pending investigation into its life history.

SUMMARY.

A taxonomic study has been made of the Paramphistomidae occurring in domestic ruminants in Australia.

Three species were recognized, namely, *Ceylonocotyle streptocoelium* (Fischöeder, 1901) Näsmark, 1937, *Paramphistomum ichikawai* Fukui, 1922, and *Calicophoron calicophorum* (Fischöeder, 1901) Näsmark, 1937. There is possibly a fourth species, as yet undetermined.

Acknowledgements.

The author wishes to thank Dr. Ben Dawes, University College, London, and Dr. F. W. Price, Zoological Division, Bureau of Animal Industry, Department of Agriculture, Washington, D.C., U.S.A., for their interest and advice.

Thanks are also accorded the various people who forwarded specimens, particularly Mr. W. Kearney, Inspector of Stock, Oxley.

This work was carried out as part of the research programme of the Division of Animal Health and Production, C.S.I.R.O.

References.

- DAWES, B., 1936.—On a collection of Paramphistomidae from Malaya with a Revision of the Genera *Paramphistomum* Fischöeder 1901 and *Gastrothylax* Poirier 1883. *Parasitology*, 28: 330-354.
- , 1946.—The Trematoda. Cambridge Uni. Press, London.
- DURIE, P. H., 1949.—A preliminary note on the life cycle of *Paramphistomum cotylophorum* (Fischöeder, 1901) and *P. cervi* (Schrank, 1790) etc. *Aust. Vet. J.*, 25 (9): 209.
- EDGAR, G., 1938.—Paramphistomiasis of young cattle. *Aust. Vet. J.*, 14: 27.
- FISCHÖEDER, F., 1901.—Die Paramphistomiden der Säugethiere. *Zool. Anz.*, 24 (646): 367-375.
- MAPLESTONE, P. A., 1923.—A revision of the Amphistomata of Mammals. *Ann. Trop. Med. Paras. Uni. of Liverpool*, 27 (2): 113-212.
- NÄSMARK, K. E., 1937.—A revision of the Trematode Family Paramphistomidae. *Zool. Bidrag Uppsala*, 16: 301-565.
- ROBERTS, F. H. S., 1934.—Worm parasites of domesticated animals in Queensland. *Queensland Agric. J.*, 41 (3): 245-252.
- ROSS, I. C., and GORDON, H. McL., 1936.—The Internal Parasites and Parasitic Diseases of Sheep. Angus and Robertson, Sydney.
- SEDDON, H. R., 1947.—Host check list of helminth and arthropod parasites present in domesticated animals in Australia. C. of Aust. Dept. of Health, Service Publication No. 2.
- STILES, W., and GOLDBERGER, J., 1910.—A study of the anatomy of *Watsonius watsoni* (n.g.) of man of nineteen allied species of Mammalian Trematode worms of the superfamily Paramphistomoidea. *Hyg. Lab. Bull. No. 60*: 1-261.
- TRAVASSOS, L., 1934.—Synopsis dos Paramphistomoidea. *Mem. Inst. Oswaldo Cruz.*, 29 (1): 19-178.
- WILLMOTT, S., 1950.—Gametogenesis and early development in *Gigantocotyle bathycotyle* (Fischöeder, 1901) Näsmark, 1937. *J. Helminth.*, 25 (1-2): 1-14.

EXPLANATION OF PLATES IV-V.

PLATE IV.

Ceylonocotyle streptocoelium.

1. Median sagittal section through the acetabulum showing structure and arrangement of the circular musculature, $\times 60$. de, Dorsal exterior circular layer; di, Dorsal interior circular layer; Ra, Radial muscle fibres; vi, Ventral interior circular layer; ve, Ventral exterior circular layer.

2. Median sagittal section through the genital atrium, $\times 184$. GP, Genital papilla; GS, Genital sphincter, SP, Sphincter papillae; ♂, ductus ejaculatorius; ♀, uterus.

3. Median sagittal section through Laurer's canal and the excretory canal, $\times 60$. EC, Excretory canal; LC, Laurer's canal.

4. Median sagittal section through part of the pharynx and oesophagus, showing a well-developed oesophageal sphincter, $\times 184$. INT, Intestine; Oe, Oesophagus; OeS, Oesophageal sphincter; Ph, Pharynx (portion of).

PLATE V.

Ceylonocotyle streptocoelium.

5. Median sagittal section, showing the position and size of the pharynx, genital atrium and acetabulum, $\times 18$. Ac, Acetabulum; DuE, Ductus ejaculatorius; EB, Excretory bladder; GA, Genital atrium; Oe, Oesophagus; OV, Ovary; Ph, Pharynx; PM, Pars musculosa; T, Testes; Ut, Uterus.

Paramphistomum ichikawai.

6. Median sagittal section, showing the position and size of the pharynx, genital atrium and acetabulum, $\times 15$. Ac, Acetabulum; GA, Genital atrium; Oe, Oesophagus; Ph, Pharynx.

7. Median sagittal section of the acetabulum showing structure and arrangement of the circular musculature, $\times 42$. de₁, Dorsal exterior circular layer 1; de₂, Dorsal exterior circular layer 2; di, Dorsal interior circular layer; Ra, Radial muscle fibres; ve, Ventral exterior circular layer; vi, Ventral interior circular layer.

8. Median sagittal section through the genital atrium, $\times 60$. GP, Genital papilla; SP, Sphincter papillae; Ra, Radial muscle fibres; σ , Ductus ejaculatorius; ♀ , Uterus.
Calicophoron calicophorum.

9. Median sagittal section through portion of the acetabulum showing the lateral circular muscle layer, $\times 180$. l, Lateral circular muscle layer; ve, Portion of ventral exterior circular layer; vi, Portion of ventral interior circular layer.

10. Median sagittal section through the genital atrium, $\times 60$. GP, Genital papilla; GS, Genital sphincter; Ra, Radial muscle fibres; SP, Sphincter papillae.